STATE & PRIVATE FORESTRY
FOREST HEALTH PROTECTION
SOUTH SIERRA SHARED SERVICE AREA

Report SSSA 14-3

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To: **Woody Smeck, Park Superintendent, Sequoia-Kings Canyon National Park**
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Subject: **Evaluation of Recent Tree Mortality at Cedar Grove Recreation Area, Sequoia-Kings Canyon National Park**

BACKGROUND: In 1983, Forest Health Protection pathologist, John Pronos, and entomologist, Dave Schultz evaluated elevated tree mortality in four campgrounds of the Sequoia-Kings National Park at Cedar Grove (Pronos and Schultz 1983, Report 83-09). They determined that preceding years of low annual precipitation from 1979-1981 inversely correlated to elevated bark beetle activity. Stand factors such as overstocking, dense canopies, and shifting tree species also contributed to predisposing trees to insect infestations. Chronic issues like root disease and dwarf mistletoe accounted for most of the pathogen-related tree mortality. Abiotic factors like poor water holding capacity of the soils, and very low river levels only compound overall tree stress. Over 50 trees had died in 1983 in the four campgrounds.

Earlier this spring, Forest Health Protection pathologist, Martin MacKenzie, and entomologist, Beverly M. Bulaon met with Park Forester, Tom Warner (who went out with Pronos and Schultz back in 1983), to evaluate current mortality assessed in the same campgrounds as well as surrounding forests. Total for the four campgrounds for 2013, and current tallies for 2014 (table 1) are as follows:

Table 1. Summary of (Dead) Trees identified for Removal from Cedar Grove

Sites (Cedar Creek Area)	**Trees for Removal 2013**	**Trees for Removal 2014** (*updated 4/21/14)*
Sheep Creek Campground	246	313
Canyon View Campground	118	57
Moraine Campground	142	186
Sentinel Campground	131	64
Grand Totals	**637**	**620**

Totals for surrounding forests significantly put these numbers well above 700 trees requiring removal.

The same insect and disease issues observed in 1983 were also noted in 2014. The main difference is that tree mortality is much more severe and appears to be increasing, that hazards to the visiting public and Park personnel are numerous and widespread. This evaluation will reflect on the 1983 report as well as focus on some new recommendations in the context of potential climate change while encouraging ecological restoration and public safety.

Introduction

The Cedar Grove recreation area in the Sequoia-Kings Canyon National Park is located at 4600 to 5100 feet, along the South Fork Kings River. These are high-use campgrounds and recreation area. There are several other high priority administrative sites in addition to the campgrounds: multiple employee barracks/camps, two fire crew stations, three visitor centers, horse stables, and village market. The bridge from Sheep Creek campground to the market has been renovated, and prescribed burns have been run through various locations in the rec area as recent as last year. Tree removals have always been ongoing throughout the park, but this year crews have been very busy in Cedar Grove alone.

Forest vegetation in the Cedar Gove recreation area is considered mixed-conifer pine type. Densely stocked areas such as Sheep Creek campground are evenly stocked with white fir, incense cedar, and black oaks along with ponderosa and sugar pines. Understory regeneration is mostly white fir or incense cedar since canopy cover is over 50% for most sites. Moving up eastward towards Canyon View and Moraine, vegetation begins thinning considerably towards predominantly Ponderosa and Jeffrey pines. Most pines are of younger age classes, but larger diameter pines (>30 inches) can be found scattered in the landscape. Sheep Creek and Sentinel Campgrounds have more organic matter in the soil than decomposed granite, which makes them better growing sites; compared to Canyon View and Moraine Campgrounds which have very porous soils with less water holding capacity.

Table 2 below was taken from Pronos and Schultz (1983) of pests identified at Cedar Grove, with a few current additions:

Table 2. Pests associated with tree mortality at Cedar Grove and their hosts.

	Pest	Cedar Grove tree hosts
Insects	Western Pine Beetle (*Dendroctonus brevicomis*)	Ponderosa pine
	Jeffrey Pine Beetle (*Dendroctonus jeffreyi*)	Jeffrey pine
	Fir Engraver (*Scolytus ventralis*)	White fir
	California Flatheaded Borer (*Phaenops californica*)	Most pines, except lodgepole
	Red Turpentine Beetle (*Dendroctonus valens*)	Most pines
	Mountain Pine Beetle (*Dendroctonus ponderosae*)	Ponderosa, Sugar pines
	Cedar Bark Beetles (*Phloeosinus* sp.)	Incense Cedar
	Woodborers (general)	All pines and true firs
Diseases	Dwarf Mistletoe	All Pines and true firs
	Annosum Root Disease (*Heterobasidion occidentale*)	True firs
	True Mistletoe (*Phoradendron juniperium*)	Incense Cedar
	White Pine Blister Rust (non-native; *Cronartium ribicola)*	Sugar pine
Injuries	Mechanical	All species
	Fire	All species

Discussion

All insects and pathogens listed in Table 2 are native except for White Pine Blister Rust (*Cronartium ribicola*). Native insects have natural controls (biotic and abiotic) that regulate populations; however, conditions may change that favor insect survival and expansion. Bark beetles in particular, take full advantage of these opportunities: warmer than average winter temperatures improve overwintering brood survival; suitable hosts available in large numbers; or disturbances that cause injury to trees. In California when drought becomes severe and prolonged, trees lose vigor and consequently, bark beetle-associated mortality increases. Oblinger et al. (2011) and Guarin and Taylor (2005) found that three to four years of consecutive lower-than-average precipitation will inevitability lead to surges in bark beetle morality – in all sizes and age classes.

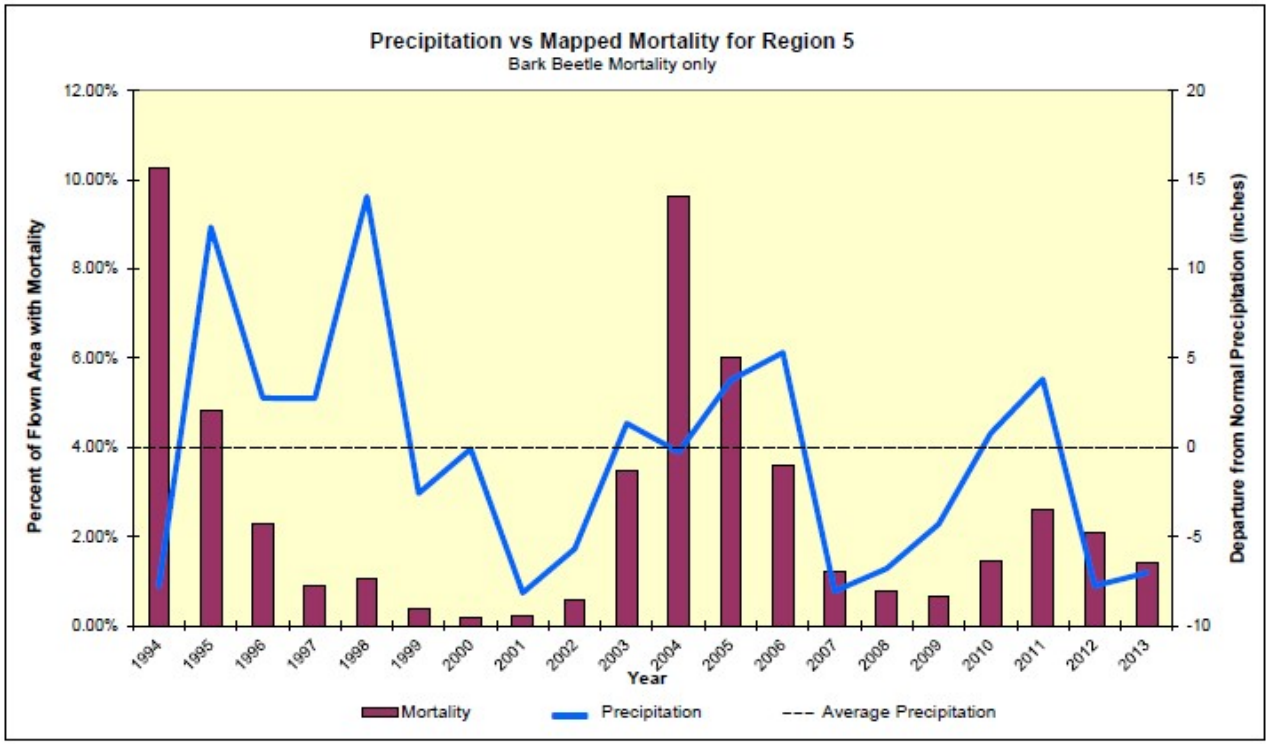

Figure 1. *Graph of Average Annual Precipitation and corresponding bark beetle mortality detected by Aerial Detection Survey, Forest Health Monitoring*

The large pockets of tree mortality in 2013 are a testament to the rapid adaptations of bark beetles when conditions are favorable. Western pine beetle (WPB) prefers large diameter and fairly weakened trees – which typically have compromised defense mechanisms. The inability to physically expel and repel attacking beetles explains lack of pitch tubes associated with WPB attacks. Western pine beetle kill-pockets as large as 30+ ponderosa pines trees were easily visible driving along the byway, particularly at the Lewis Creek Spike Camp (>100 trees) and Moraine Campground (>50 trees). Areas where tight groups of ponderosa pines exceeded >120 ft^2/ac were targeted by the WPB, but beetles still moved through campgrounds attacking ponderosa pines over 13 inches. An estimated 30% of the overstory appears to be dead in Lewis Creek (see Figures 2 and 3). As opportunists, WPB found many spots along the main road that fit prime conditions. Some of the smaller diameter pines did not have evidence of infestation, nor disease; it was concluded that these trees were most likely dying from water stress. Current population levels of WPB would be considered incipient, as older attacks are coalescing with new attack and mortality levels are increasing.

Click to zoom in on the time slider.
1987
2012
Google earth
Imagery Date: 5/30/2014 36°48'04.72" N 118°41'30.91" W elev 4610 ft eye alt 5791 ft

Figure 2. *Satellite Google Earth® image of the Lewis Creek Spike camp, May 30, 2014. Note red canopies are dead ponderosa pines.*

Figure 3*. Photo taken from the highway looking into Lewis Creek Spike Camp.*

Factors contributing to tree stress were site-related as seen in singular large sugar pines (20 inches diameter-at-breast height (DBH)) attacked by mountain pine beetle, within dead ponderosa pine groups killed by western pine beetle. Incense cedars – a species with no primary insect mortality agent – were also found fading in many of the same areas as pines (see Figure 4). Crowns of cedars were already thinning, a symptom of decline. Often no diseases or insects were found associated with declining incense cedars; occasionally *Phloesinus sp*. infesting already dying trees. More large groups (5-10 trees) of ponderosa pines attacked by WPB were found further east around Zumalt Meadow and Roads End Permit Station. As sites became more rock soil-based rather than organic matter, tree mortality was more evident.

Figure 4. *Dead incense cedar near pocket of ponderosa pines killed by bark beetles.*

On the opposite end, Sheep Creek campground has most tree losses in the white firs. While soil moisture holding capacity is better in the campground than others, density and tree stocking are very high. Average basal area was about 300 ft^2/acre, with a large component being white firs. Tree crowns were very short, with almost 80% crown cover in some areas. Fir stumps show symptoms of laminations, possible root disease, but no conks were detected. High levels of stocking create competitive stress on trees when resources and space become very limited. This also makes trees more susceptible to mortality due to forest pests.

The mortality levels at Cedar Grove Recreation Area are fairly high but not surprising due to the on-going drought. The drought situation in California is currently the fourth worst in the state's history. While there were several years of below normal precipitation in the early 1980's, the current drought is setting records. Across the state, many rivers are at or below 50% averages. This drought started back in 2007 when precipitation was 8-9 inches below normal – the worst since 2001. Good weather picked up for 2011, but trees may have already been on a trajectory for decline as mortality remained high in 2012 (see Figure 1). Older dead trees among the recently killed (estimated killed three to five years ago) show that bark beetles have been very active and moving among stands as drought conditions intensified.

Not surprising that Sheep Creek had the highest level of tree death – as a better growing site, more trees establish there. However the high basal areas, higher tree stocking, or high percent crown closures have been correlated with significant resource inter-tree competition. In the thirty years since Pronos and Schultz (1983) visited this area, many new trees – primarily white fir – have filled in openings, but managed fuel reduction treatments have been conducted to reduce the potential for catastrophic wildfire. However, bark beetles continue to find disease-weakened trees, or trees suffering water stress. In the past, the Park was very proactive in mitigating pathogens, removing bark beetle-infested trees, and spraying preventive insecticides on green trees. While times have changed, some management treatments are still viable and encouraged.

As suggested in 1983, a detailed vegetation management plan is encouraged that details multiple management alternatives to achieve long-term objectives and goals for campgrounds in the Cedar Grove Recreation Area as well as other high-priority sites for the Sequoia-Kings National Park. Hazard tree management and future desired conditions would help guide strategies that provide for public safety and safe

recreation. Prevention is always the best management tool for minimizing risk and unwanted losses due to pests. As trends of warming temperatures with less precipitation are occurring and are predicted to continue, a long term vegetation management plan would help the Park adapt should pest conditions worsen or change.

Management Suggestions

Below is a list of suggested management options that can be implemented for *reducing hazards* (taken from *Hazard Tree Guidelines for Forest Service Facilities and Roads in the Pacific Southwest Region*, Angwin et al 2012 *draft*). Bark beetle suppression is not feasible at this point in time: populations are high and many areas would need immediate treatments. Prevention against potential mortality by bark beetles next year can be implemented that may help protect residual trees.

- *Remove dead trees.* This can include *currently infested* green trees with bark beetles since they will turn color by the following year. Identify all potential hazards following Park guidelines, particularly high risk target areas like campgrounds, paved roads, and administrative sites. All dead trees that could impact a target should be removed.
- *Target removal.* If trees – dead or alive – are valuable, then remove target to remove risk.
- *Topping.* Topping a tree may be the best option if removal is not an option. Topping may reduce top weight in the upper half or height of the tree where it could fail and hit targets.
- *Pruning.* Pruning is encouraged if branches, dead tops, or multiple tops are the main concern. Proper pruning of dwarf mistletoes or other pathogens may help prolong the life of a tree.
- *Root disease prevention.* To prevent the introduction of *Heterobasidion sp*. root disease (aka Annosum), it is highly recommended to apply a registered borate-compound to all freshly cut stumps greater than 3 inches across.

While *No Management* alternative is an option, the liability of personal injury or property damage should be considered and weighed against this possible treatment. While dead trees are extremely valuable in forested ecosystems for multiple reasons, public safety in areas of high visitor-use should be a priority. There are many options for which pest prevention/mitigation and conservation of resources can be achieved. Forest Health Protection can help provide further information.

The following management suggestions for long-term prevention of forest insects and diseases was outlined by Pronos and Schultz (1983), but are re-iterated here to further emphasize their importance as general practices for improving and maintaining healthy forest conditions.

- *Reducing tree competition, providing adequate growing conditions.* Silvicultural thinning to proper stocking levels will help evenly distribute resources for trees. Inter-tree competition weakens trees and makes them more susceptible to bark beetle infestation or disease infection. Improving stand conditions improve tree vigor and resistance mechanisms against bark beetle attack. When selecting trees for removal, trees free of dwarf mistletoe infection should be favored. Trees displaying poor crown conditions or injury should be examined for bark beetle infestation or possible disease infection.
- *Reducing Dwarf Mistletoe infection.* While this may seem daunting in some areas where infection is high; where infection is low or initiating, pruning of brooms or removal of heavily infected trees can reducing further spread into the stand. A dwarf mistletoe project in 1967 was completed in which Canyon View and Moraine campgrounds were treated of the most severe infections, leaving Sheep

Creek and Sentinel campgrounds to still be treated. In 1981, a separate evaluation of Cedar Grove by Pronos detailed procedures for dwarf mistletoe management which led to a dwarf mistletoe control project funded by NPS and Forest Service. From 1984 to 1992, all four campgrounds and surrounding buffer areas (263 acres) were each treated three times (3 separate entries) to reduce dwarf mistletoe through pruning or tree removal (Pronos et al. 1995, Warner 1985). The project was assessed in 1985: a total of 2995 trees were treated in all four campgrounds. In Sheep Creek alone, almost half of removed trees in 1984 were less than 11 inches in diameter (Pronos et al. 1995). While it was concluded that infection and inoculum sources were significantly decreased, complete eradication dwarf mistletoe is not possible due to difficulties of detection in all trees (especially latent infections), and over such a large area. However, past treatments effectively reduced the need for further management of dwarf mistletoe for many years. Thirty years later, this seems to be the case. Maintenance of low infection levels is the best strategy for continued suppression of this parasite before overall levels become severe.

- *Increasing stand diversity*. Diversity (age, size, species, etc.) is a key to pest prevention. Less availability of susceptible hosts, preferred species, and differences in pest complexes help keep overall tree mortality low. If possible, planting rust-resistant Sugar pines will help perpetuate the species and reduce the incidence of Blister Rust. Favoring hardwood species, encouraging brush patches that break up stand structure can significantly alter microclimate or conditions that are favorable for infestation.
- *Disease prevention.* As stated previously, treatments of freshly cut stumps – firs and pines – with a registered borate compound can greatly reduce incidence of native root diseases. Stump removal or fumigation were previously recommended, but are not widely practiced and not found to be highly effective. *Heterobasidion irregular* (P-type) root disease has not yet been detected in the Park, but prevention treatments can keep it from being introduced.
- *Minimize injury.* Fire can cause additional injury to water-stressed trees, making them vulnerable to bark beetle attack particularly during drought years. Avoid injury during landscape or construction projects.

SUMMARY

Many more trees have continued to fade since the field visit. About 700 trees were tallied in all campgrounds, administrative sites, and general surrounding forests of Cedar Grove Recreation Area at the beginning of summer, and additional cruises have found more. Temperatures have been higher than average for most of the state and summer storms have been few. If the drought continues into 2015, it is certain that more pines will continue to fade, especially on rocky, drier, or overstocked sites. It would be recommended that ground disturbances such as prescribed fires or major construction be delayed until overall water conditions improve in the Grove so trees can recover some vigor. Damage to root systems or mechanical injury to trees can increase susceptibility to forest pests.

Forest Health Protection will continue to visit this site as the numerous potential hazards and high tree mortality levels are additional indications of what we are witnessing in many other parts of the Sierras the past few years. If there are any further questions regarding this report or more information is needed, please do not hesitate to contact us.

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